A Virtual Environment for Naval Flight Deck Operations Training

Dr. Venkat V.S.S. Sastry[1]
Mr. Joseph Steel
Applied Mathematics & Operational Research Group
Cranfield University
RMCS Shrivenham
Wilts SN6 8LA, UK

Lt. Edward A. Trott
Defence Procurement Agency
Abbey Wood
Bristol
UK

Abstract
The main aim of this paper is to develop a prototype virtual environment for training Flight Deck Officers with a view to study the types of interactions required in such an environment. The application is ideally suited to exploit techniques based on proprioception, in particular the trainee's arm signals.

1. Introduction

A virtual environment is *a synthetic sensory experience that communicates physical and abstract components to a human operator or participant* (Kalawsky, 1993). Virtual Environments (VE) offer greater potential to enhance the communication between the human and the computer as they offer most intuitive and natural interfaces. They have been exploited in diverse applications ranging from medicine to training soldiers. Their potential is far more evident in training applications (Nemire, 1998) for the enriched interaction styles such environments support. A typical VE synthesises one or more sensory inputs to facilitate a particular user's task. Exploiting proprioception (sensory awareness of parts of the body) enhances interaction in a virtual environment (Mine, 1997). One form of proprioception is the use of body-relative actions called gestures to issue commands to alter the environment. Current research work in this area includes two-handed input (Hand, 1997) and gesture-based interaction (Mapes & Moshell, 1995). The gestures involved in the present application are quite unique, and thus provide an ideal test bed for exploring 3D interactions in VE.

Training Flight Deck Officers (FDO) is an important aspect of Naval operations and currently uses a range of traditional teaching material augmented by instructor-assisted scenario generation (AIR 230 Course). The instructor directly controls the scenario presented to the trainee. While this approach has some strength, we believe that a virtual environment offers much significant benefits and that the application readily lends itself to exploit the natural interaction styles, such as arm signals, that are inherent in the training of Flight Deck Operations (Trott, 1999). At the same time, the application raises several challenges. The main purpose of this article is to present the results of our initial prototype, with a view to enhance the model. The development of the application is by no means complete, and should be treated as an initial investigation.

The paper is organised as follows. A brief motivation is presented in Section 2. The problem we are attempting to address in this paper is described in Section 3, together with typical training scenarios. The details of developing the Virtual Environment are given in Section 4. Some of the points highlighted in developing the prototype are summarised in Section 5.

2. Rationale

Exploiting natural interaction metaphors offered by the application can enhance the current set up for supporting the training of Flight Deck Officers. The main motivation for the present study can be summarised as follows.

- To provide an enhanced training environment for the trainee.
- To allow interactions using natural metaphors that will enhance the experience of a flight deck officer in which he/she will be able to control the environment in response to his/her actions. For example, ask the helicopter to move to the next gate position in response to an arm signal.

3. The Problem

Current Practice

Currently the British Royal Navy Flight Deck Officers (FDO) are trained at RNAS Culdrose, Cornwall, England. Their training makes extensive use of real simulation, that is *real* people using *real* equipment. In this case the real equipment is an actual helicopter, although training is not performed on-board ship.

If the weather conditions restrict aircraft flights or aircraft are unavailable, then the training makes use of a *virtual* simulator. This consists of three large projection screens that display images from three front projectors driven by three networked PCs. The system shows the view as seen from the landing deck of a frigate. The trainee stands in front of the screens and directs the flight of the simulated helicopter using the appropriate signals. The class instructor who is sitting behind the trainee flies

[1] For correspondence with author: sastry@rmcs.cranfield.ac.uk; tel. +44 (0) 1793 785315; fax +44 (0) 1793 784196.

Paper presented at the RTO HFM Workshop on "What Is Essential for Virtual Reality Systems to Meet Military Human Performance Goals?", held in The Hague, The Netherlands, 13-15 April 2000, and published in RTO MP-058.

the helicopter. The direction of view of the system is fixed and cannot take into account the direction of view of the trainee. The current system also has limited graphics capability and environmental effects such as reduced visibility, fog and variable sea-state are barely implemented.

Although the virtual simulator is available, final examinations must be passed using the real equipment. There are two main reasons for this: the virtual simulator is unable to replicate the feel of being exposed to the prevailing weather conditions nor the feel of the proximity of the helicopter as it lands.

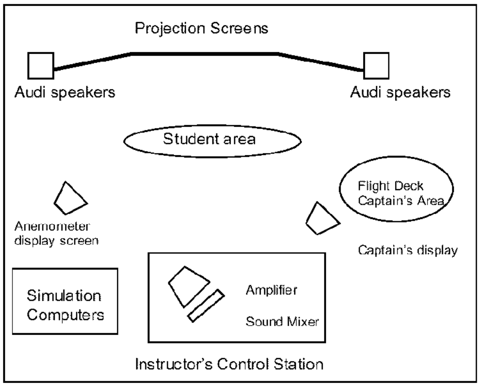


Figure 1: Flight Deck Operations Simulator

Some of the limitations cited above can be addressed by developing a virtual environment, which offers far greater potential. To explore these possibilities, a subset of training scenarios are considered for the initial design, which are explained in the next section.

Example Scenarios

Flight Deck Officer's training consists of a number of scenarios including Landing and Takeoff (varying angles of approach), Rotors Running Refuel, Helicopter In-flight Refuel, Weapons Loading, Personnel Transfer, and Helicopter Shut Down and Start Up using either a Sea King/Lynx. All these scenarios offer a rich variety of 3D interactions that enhance the learning and training experience. For the purposes of this investigation, we have selected two scenarios — Helicopter landing and take off under varying environmental conditions.

The trainee FDO immersed in the virtual environment makes an assessment of the wind speed and direction (not currently implemented) and then signals the aircraft when he is ready to receive it. It is assumed that the aircraft is out of radar-controlled approach and is within the visual range for FDO to take control. On receipt of the signal, the aircraft moves to its next waypoint or gateway. A typical approach of an aircraft to the ship's flight deck is shown in Figure 2.

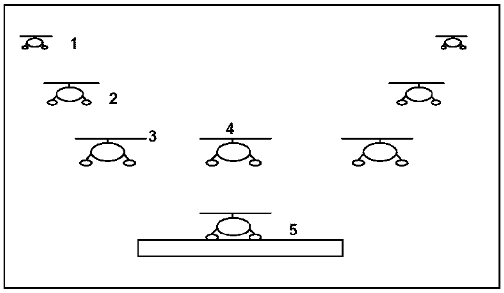


Figure 2: A typical approach of an aircraft. Helicopter begins approach relative angle 165° from ships head (1); Aircraft reaches gate (2); Aircraft alongside flight deck directly of the 'bum' line (3); Traverses across flight deck maintaining its hover (4); aircraft descends to flight deck (5).

4. Development of a Virtual Environment

The virtual environment consists of a visual model of the flight deck and its associated dynamics, a visual model of a helicopter (Sea King) and its associated dynamics, and finally a visual representation of the flight deck officer including body articulation (limited to hands). For the training purposes, few environmental effects such as fog and night time are also included. These are discussed in detail in the following sections.

Flight Deck Officer

A simple model of a mannequin is used to represent the flight deck officer. The body articulation is limited to arms only. Currently there are nearly 56 distinct gestures used by the FDO. Of these, 9 gestures (See Figures 3 and 4) which are directly relevant for launch and recovery operations are chosen for the prototype. An existing model of a man from the Division software library has been modified to facilitate the emulation of arm signals. The animation of the limbs is achieved using the keyframes animation technique where each frame describes a particular state of the object, for example its position and orientation. Each hand signal is stored as a key frame animation sequence and was stored in a separate library.

The FDO is required to carry lighted wands at night in order to make his signals visible to the pilot. Accordingly, our virtual FDO has two lighted wands, which come into effect during night
time training.

Helicopter Approach
A 3D model of the Sea King helicopter is modified to provide realistic rotor disc motion and the addition of navigation lights to the helicopter stub wings. This was achieved by mounting a spotlight just in front of the navigation light and setting an appropriate object luminescence property in the object's texture file.

The movement of the helicopter is governed by a series of keyframe sequences in a required direction. The helicopter movement is triggered by an event (such as receive, approach, move away, left, right, up, down, hold, wave off) raised by FDOs hand signal. In response to this signal, the aircraft will move to the next 'gate' position. Once the aircraft has been successfully directed over the deck, a final signal to descend to the deck is given. When the collision between the helicopter and the deck is detected, the helicopter object is parented with the deck object, so that the helicopter moves in accordance with the motion of the flight deck and that of the ship.

Platform Dynamics
The platform consists of the deck, harpoon grid and a model of the FDO standing on the deck. To keep the frame rates to a minimum, a simple animation sequence is created for the platform that emulates the motion of a ship.

Environmental Effects
Environmental effects such as lighting conditions and visibility effects can be easily incorporated into the virtual environment. To effectively light the scene and allow for a number of different lighting conditions five light sources are used. Four of these light sources are used for scenery lighting and the remaining light is used to illuminate the deck. An appropriate texture is applied to the sky to produce an impression of a marginally cloudy day. Fog is emulated using the library function *dvFog* which allows a colour and distance parameter (beyond which the objects are invisible) to be specified. Note that when fog is enabled, the sky is obscured; and affects the intervisibility computations.

Virtual Command Interface
The prototype environment is developed using the Division software dVS/dVISE. Due to the current limitations, the arm signals of the trainee are *simulated* using virtual menus (See Figure 5). A limited number of training manoeuvres is implemented for helicopter landing and takeoff under different environmental conditions. The use of directional sound is also explored with limited success. Note that for a fully functional immersive environment, appropriate hardware, and additional software for gesture analysis should replace the virtual menus mentioned above.

5. Remarks
As the main focus in this study on developing a virtual environment for training, no specific experiments were conducted to evaluate the overall benefit of such a system. However, the exercise has revealed several important factors.
Top most in the list is the need for a software component for gesture interpretation. The computational demands for training purposes are moderate, as the objects in the virtual environment remain fairly static. Selection of items using Virtual menus is not intuitive, and could be enhanced using additional visual cues.

The next stage of the work is an investigation into the recognition of various arm signals using a single tracking device in each hand. Simply knowing where each hand and it's orientation is insufficient. It is expected that knowledge of how each hand has recently moved will be required to determine the relevant signal. For example, arm signals for FDO Up and FDO Down (See Figure 4) trace the same path, but differ in start and finish positions. We envisage that it will not be necessary to have tracking devices at either the elbows or shoulders. The use of a neural network to facilitate this task is expected.

6. Conclusions
The prototype environment for FDO training has highlighted some of the requirements that are essential for a fully immersive tool. There is a clear need to track the position of both head and two arms. While the current tracking system is capable of tracking position data up to four trackers, this is not currently implemented, and will be pursued in a future investigation. Use of directional audio cues have been explored very briefly, but needs a detailed study.

References

AIR230 Course. Royal Naval School of Flight Deck Operations. See also Windows User Guide.

Hand, C. (1997). A Survey of 3D Interaction Techniques. *Computer Graphics Forum, 16 (5),* 269–281.

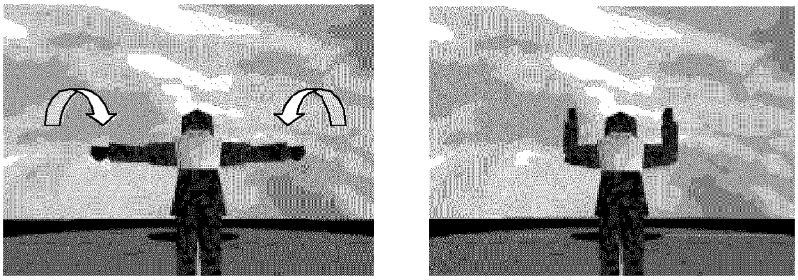
Kalawsky, R.S. (1993). From visually coupled systems to virtual reality. An aerospace perspective. *Proceedings Computer Graphics, 91.*

Nemire, K. (1998). Individual combatant simulator for tactics training and mission rehearsal. *SPIE Proceedings, The Engineering Reality of Virtual Reality, 3295,* 435–441.

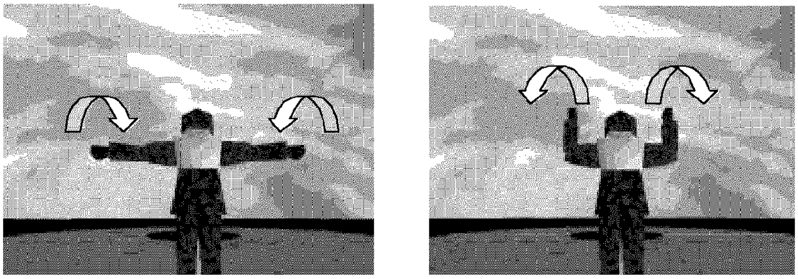
Mapes, D. & Moshell, J.A. (1995). A Two-Handed Interface for Object Manipulation in Virtual Environments. *Presence: Teleoperators and Virtual Environments, 4 (4),* 403–416.

Mine, M. (1997). *Exploiting Proprioception in Virtual Environment Interaction.* PhD Thesis, University of North Carolina, Chapel Hill, Computer Science Technical Report, TR97-014.

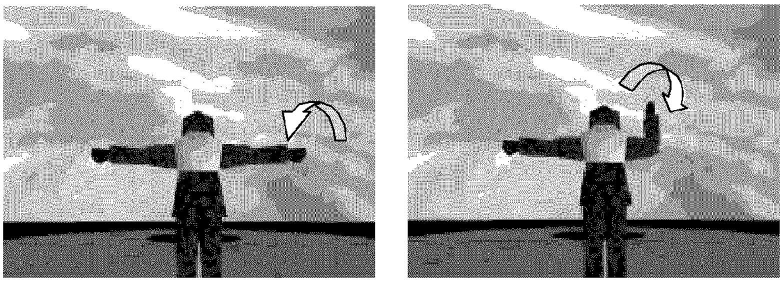
Trott, E.A. (1999). *An Investigation into the use of Virtual Reality for Naval Flight Deck Operations Training.* MSc Project report, Cranfield University, Royal Military College of Science, Shrivenham.



FDO Ready to receive – you are cleared to land



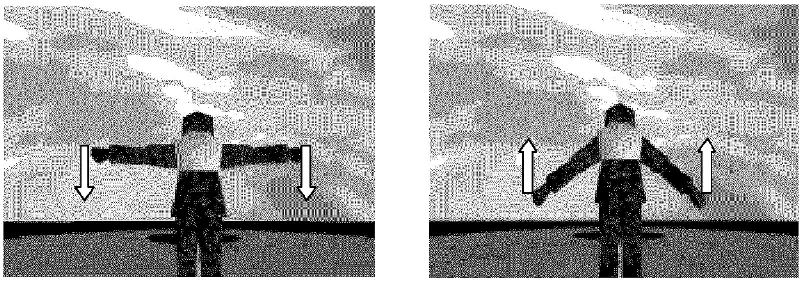
FDO Approach



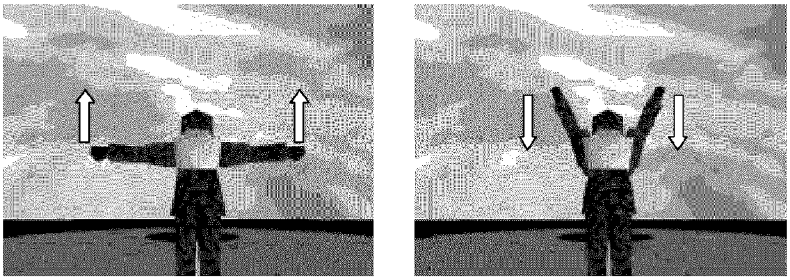
FDO Move left

FDO Move right

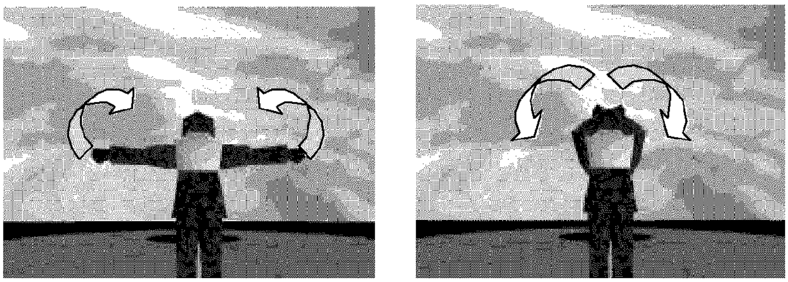
Figure 3: A subset of Flight Deck Officer's hand signals



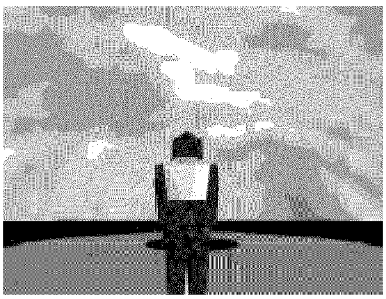
FDO Down



FDO Up



FDO Wave-Off



FDO Hold

Figure 4: A subset of Flight Deck Officer's arm signals (ctd.)

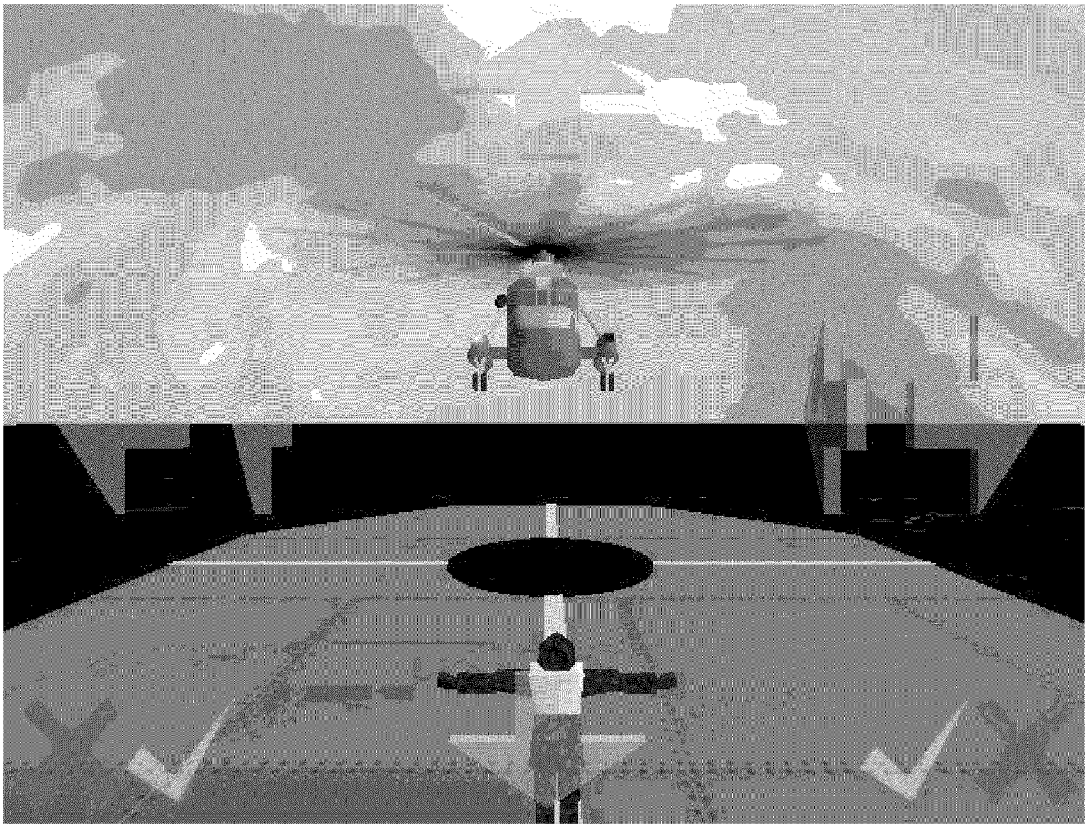


Figure 5: Virtual menues used in the virtual environment